Unit: Quantities in Chemical Reactions	Grade: 11	
Lesson Sequence	**Lesson Plan Title (Concept)**	**Names**
First Lesson	Multi-Step Mole Conversions: Students will learn how Avogadro's number, the mole and molar mass are interrelated by (1) creating a unique analogy and (2) solving multi-step mole conversion problems. Students will understand why these conversions are important for health care and the environment.	Karen Founk, Danielle Skoufranis
Second Lesson	The Limiting Reactant: Students will apply prior knowledge of mole conversions and mass relationships to find the limiting reactant in a chemical reaction.	Shannon Mendes, Rena Tam

Rationale: We selected lesson plans from the beginning and end of the *Quantities in Chemical Reactions* unit because we wanted to create lesson plans that provide a comprehensive view of this topic. Lesson 1 teaches students the core concepts regarding the mole, Avogadro's number, and molar mass and is later used in Lesson 2 to identify the limiting reagent in a reaction. Lesson 1 and Lesson 2 are linked through our big idea – that knowledge of mole chemistry is useful and practical to society, particularly in health-care and the environment.

Course: EDU1480 Chem I/S – Fall 2011

Instructor: Cheryl-Ann Madeira

Date: September 21, 2011

Assignment: Lesson Plan

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Qualitative and Quantitive Analysis and Unit Conversions **1**	The Mole (Avogadro's Number) **2**	Molar Mass (Mole=Mass/Molar Mass) **3**	Mass and Number of Entities (Calculations & Conversions) **4**	Integrating Mole Lessons (review to date) - **LESSON ATTACHED** **5**
Mole Quiz and Percentage Composition **6**	Law of Definite Proportions **7**	Empirical Formulas and Molecular Formulas (1) **8**	Empirical Formulas and Molecular Formulas (2) - application to real life (ex. mass spec.) **9**	Lab - Determining Formula of Hydrates **10**
Mole Ratios in Chemical Equations; assignment on mole ratios and mass relationships (due on the 14th) **11**	Mass Relationships in Chemical Equations **12**	Limiting Reagent (1) - **LESSON ATTACHED** **13**	Limiting Reagent (2); assignment on mole ratios and mass relationships due **14**	Percentage Yield; return assignment **15**
Review **16**	Unit Test **17**	**18**	**19**	**20**

UNIT & TITLE OF LESSON: Quantities in Chemical Reactions – Multi-Step Mole Conversions

CURRICULUM CONNECTIONS

BIG IDEAS

- Relationships in chemical reactions are interrelated and can be described quantitatively.
- Avogadro's number, the mole and molar mass are important to health care professionals, the environment and society.

OVERARCHING QUESTION

How are quantitative descriptions of Avogadro's number, the mole, and molar mass related and why are accurate calculations important to health care professionals, the environment and society?

SPECIFIC EXPECTATIONS

A1.1. Formulate relevant scientific questions about observed relationships
A2.1. Identify a variety of careers related to the fields of science
D1.1. Analyse processes in the home, the workplace, and the environmental sector that use chemical quantities and calculations, and assess the importance of quantitative accuracy in industrial chemical processes;
D2.3. Solve problems related to quantities in chemical reactions by performing calculations involving quantities in moles, number of particles, and atomic mass
D3.1. Describe the relationships between Avogadro's number, the mole concept, and the molar mass of any given substance.

PRIOR KNOWLEDGE

1. The mole is used to describe quantities in chemistry
2. 1-step conversions - Moles can be converted to grams or particles using molar mass and Avogadro's number

LEARNING GOALS

1. Students learn that mole conversions do not change the quantity of a substance – they change the way the quantity is described
2. Students create a unique real-life analogy for multi-step conversions
3. Students present analogy to class and practice communication skills
4. Students learn to solve multi-step mole conversions problems
5. Students apply multi-step mole conversions to solve real-life applications and identify careers that use these calculations

MATERIALS

- ☐ Colouring Markers
- ☐ Chart Paper

APPENDICES

- ☐ *Chalkboard Note 1*
- ☐ *Mole Jokes* – Appendix 1
- ☐ *Review of 1-Step Mole Conversions* – Appendix 2
- ☐ *Chalkboard Note 2*
- ☐ *Creating Unique Mole Conversion Analogies* – Appendix 3
- ☐ *Chalkboard Note 3*
- ☐ *Using Multi-Step Mole Conversions in Professional Settings* – Appendix 4
- ☐ *Traffic Light* – Appendix 5
- ☐ *Chalkboard Note 4*

ASSESSMENT AND EVALUATION

Knowledge/Understanding

- Accurate understanding of the mole concept and mole terminology
- Develop meaningful understanding of relationships and analogies between moles, Avogadro's number, and molar mass

Thinking/Investigating

- Solve 1-step unit conversions and multi-step mole conversions

Application

- Linking careers, health-care and the environment to mole chemistry (STSE)

Communication

- Presentation to class using visual art, drama, or graphic organizer
- Use appropriate scientific terminology (mole, Avogadro's #, molar mass)

ASSESSMENT TOOLS

- Blackboard solutions (AfL)
- Thumbs up/thumbs down (AfL)
- Anecdotal comments (AfL)
- Class Presentations (AfL)
- Traffic lights self-reflection (AaL) and handed in to teacher (AfL)

DIFFERENTIATED INSTRUCTION

Knowledge of students: Differentiation based on student:	*Differentiated instruction response*
☐ *Interests*	☐ *Learning materials (content)*
☐ *Preferences – styles, intelligences*	☐ *Ways of learning (process)*
	☐ *Ways of demonstrating learning (product)*
	☐ *Learning environment*

TIMING	TEACHING/LEARNING STRATEGY	RESOURCES/NOTES	RATIONALE
Before: Minds On (15 min)	**1. Entry-into-Class Activity (2 min)** **Agenda** – Posted by teacher **Mole Jokes –** As students are settling into class, they are asked to ponder 5 mole jokes and riddles individually	Chalkboard Note 1 *Mole Jokes* - Appendix 1	Students are occupied and engaged as they enter classroom, attendance is taken, etc. AfL – Anecdotal comments; students are reminded of mole terminology (+fun!)
	2. Diagnostic Assessment: Review of 1-Step Mole Conversions (13 min) In pairs, students complete *Review of 1-Step Mole Conversions* handout to review formulas (moles to grams, moles to particles) and basic unit conversions from previous classes (8 min) As a class, assign specific students to write solutions on the board so that entire class can check their work (5 min) Teacher summarizes main review concepts: (a) The mole is used to describe quantities in chemistry (b) Moles can be converted to grams or particles using the 2 magic triangles As a class, teacher assesses readiness to move on with thumbs up/thumbs down	*Review of 1-Step Mole Conversions* – Appendix 2 Chalkboard Note 2	AfL – Assesses prior knowledge of 1-step mole conversions (K/U) Makes new connections between prior knowledge and new knowledge that is to be learned. Pair-work promote collaborations DI: GRASP formatting in Question 3 to provide scaffolding
During: Action (45 min)	**3. Designing an Analogy: Connecting Multi-Step Mole Conversion Formulas (20 min)** Using *Creating Unique Mole Conversion Analogies* handout, teacher models the creation of an analogy that describes how mole conversions are interconnected (E.g. O Canada) (5 min) Activity 1: In groups of 3 or 4, students create their own alternative analogies, being as creative as possible, filling in handout as they go. (5 min) DI: Students create and present their analogy as a visual picture, a 0.5-1 min dramatic skit or by completing a graphic organizer. (10 min)	*Creating Unique Mole Conversion Analogies* – Appendix 3 Markers for students who choose to complete a visual picture.	Students use existing knowledge to synthesize their own concept map for how moles, Avogadro's number and molar mass are related in multi-step ways Teacher models expectations for students AfL – Students are assessed on K/U and C skills DI – presentation preferences based on multiple intelligences

	4. Analogy is Used to Solve Multi-Step Mole Conversion Sample Problems (25 min) As a class, brainstorm professions that might use mole conversions Modeling of a multi-step mole conversion sample problem solved by teacher (5 min) • Map this question back to the overarching idea! Students work individually to solve multi-step mole conversion problems on their own. Students check their work with their elbow partner. (15 min) In pairs, students compare their answers to solutions page posted by teacher (5 min)	Chalkboard Note 3 *Using Multi-Step Mole Conversions in Professional Settings* – Appendix 4	Teacher models expectations for students AfL – teacher walks around class as students are solving problems AaL – checking solutions STSE – health care professional questions, industrial chemical processes
Consolidate/Homework (15 min)	**5. Traffic Light Reflection (10 min)** Students complete a Traffic Light Reflection exit card. • Reflect on the big ideas of this lesson, • Identify areas of challenge • List remaining questions that they have **5. Homework (5 min)** Preparation for quiz. Teacher reminds students what key concepts will be assessed. Teacher suggests sample problems from textbook for extra practice.	*Traffic Light* – Appendix 5 Chalkboard Note 4	AaL – reflection by students AfL – teacher collects and reads all the cards AoL (next day's quiz)

CHALKBOARD NOTE 1 – To be written at the very beginning of class

Agenda

- BIG QUESTION:
  - How are quantitative descriptions of Avogadro's number, the mole, and molar mass related and why are accurate calculations important to health care professionals, the environment and society?
- MINDS ON:
  - Mole Jokes
  - Review: 1-step mole conversions
- ACTION:
  - Build an analogy for multi-step mole conversions
  - Solve multi-step mole conversion problems and use them to solve practical problems in health care, the environment and society
- CONSOLIDATION:
  - Traffic light reflection
  - Homework – Prepare for quiz, extra practice problems

APPENDIX 1: Warm Up Your Brain with Mole Jokes!

Name: ________________

Date: ________________

INSTRUCTIONS: Use your knowledge of the mole and Avogadro's number to find the answers to these mole riddles! Hint: Be creative!

1. What do you get when you have a bunch of moles acting like idiots?

____

2. Why was there only one Avogadro?

____

3. Why do moles love Tyra Banks?

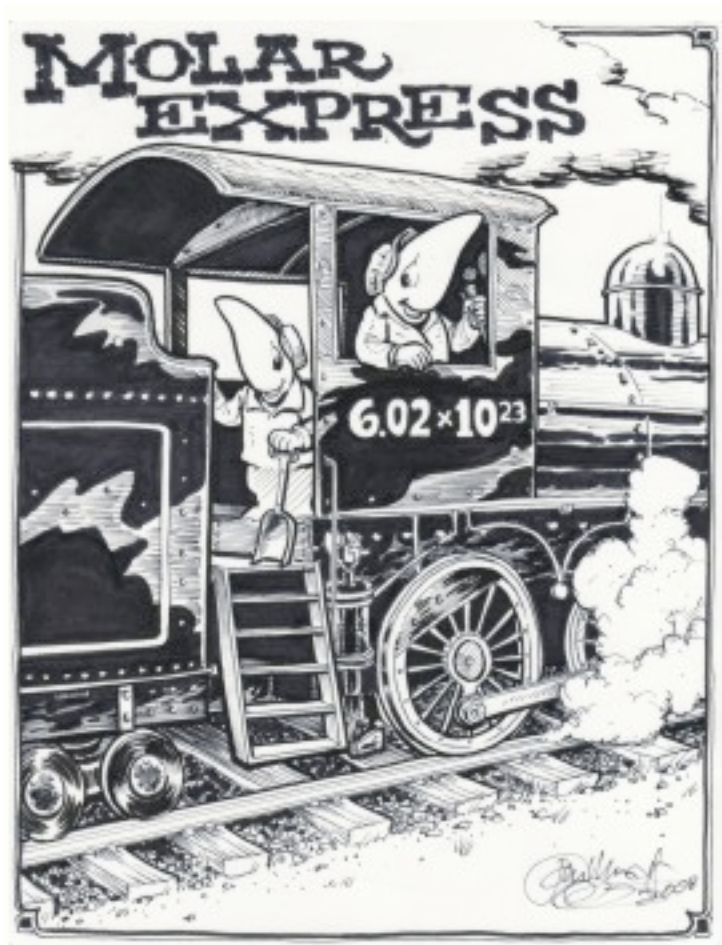
____

4. Which tooth did Avogadro have pulled?

____

5. What kind of test do student moles like best?

____



APPENDIX 1: Warm Up Your Brain with Mole Jokes!

TEACHER'S COPY

Name: ________________

Date: ________________

INSTRUCTIONS: Use your knowledge of the mole and Avogadro's number to find the answers to these mole riddles! Hint: Be creative!

1. What do you get when you have a bunch of moles acting like idiots?

A bunch of moleasses

____

2. Why was there only one Avogadro?

When they made him, they broke the Moled

____

3. Why do moles love Tyra Banks?

Because she's on America's Next Top Moledel

____

4. Which tooth did Avogadro have pulled?

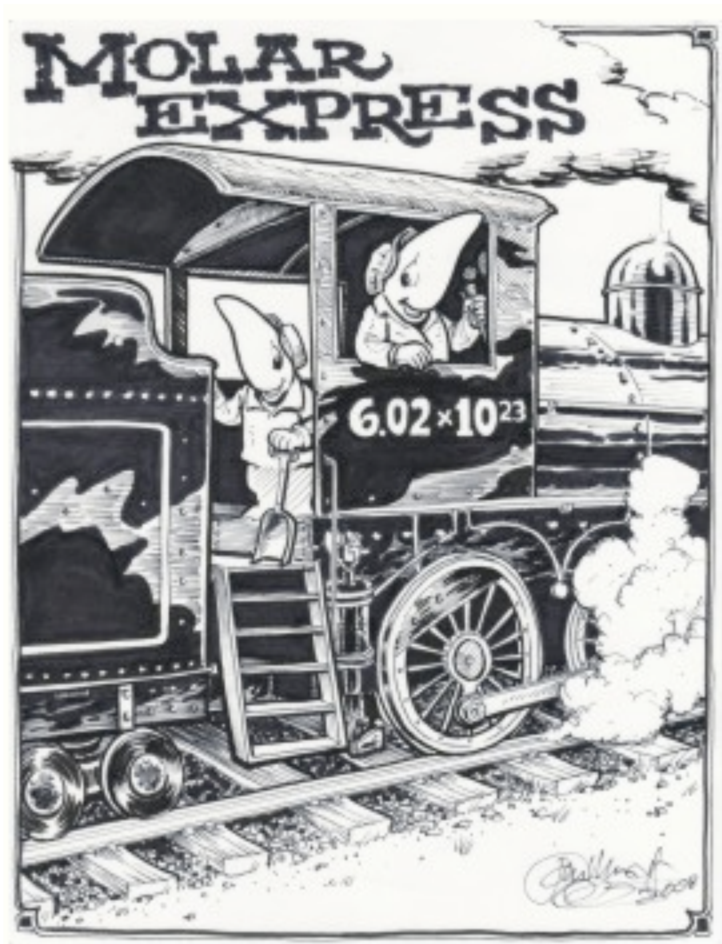
Molars

____

5. What kind of test do student moles like best?

Moltiple choice

____



APPENDIX 2: Review of <u>1-step</u> Mole Conversions

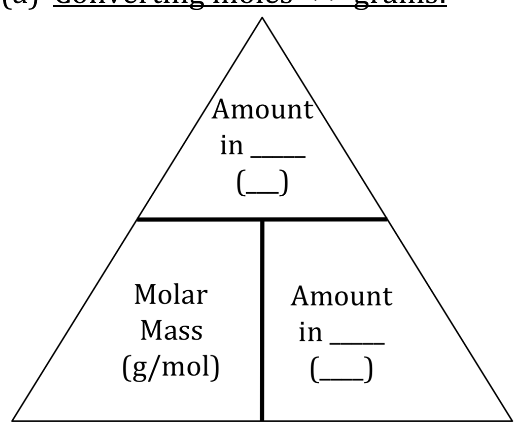
Name: ________________
Date: ________________

1. <u>Match</u> the description on the left with a description on the right [K/U]

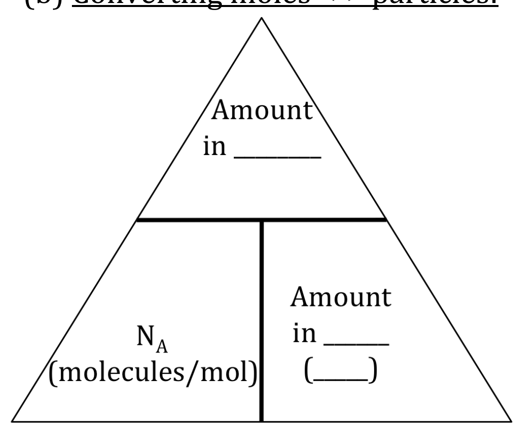
_______ 6.022×10^{23} entities	(a) 1000 g
_______ 12.01 g of carbon	(b) A chemist's dozen
_______ molar mass	(c) Avogadro's constant, N_A
_______ mole	(d) 0.1 g
_______ 100 mg	(e) exactly 1 mole
_______ 1kg	(f) Calculate using the periodic table
_______ A handful of jelly beans	(g) A qualitative description

2. Last class we learned about **TWO CONVERSION FORMULAS** that can be used to describe the <u>amount</u> of a substance present. <u>Fill in the missing labels</u> (including units) on the following magic calculator triangles: [K/U]

(a) <u>Converting moles <-> grams:</u>



(b) <u>Converting moles <-> particles:</u>



FORMULA:

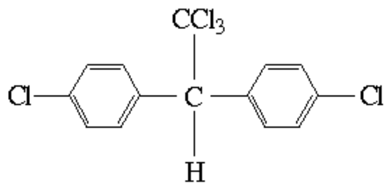
Molar mass =______________

FORMULA:

N_A = ________________

3. Last week, Mayor Rob Ford found a canister of pure DDT in his garage. The label indicates that the molecular formula of DDT is $C_{14}H_9Cl_5$. He observes that DDT is a white, crystalline powder with little odour, low solubility in water and relatively high solubility in fats.

(a) Calculate the molar mass of DDT. Remember to report your answer using appropriate units. [A]



(b) The label suggests the canister contains 0.1 kg of DDT. Use the magic triangle from Question 2(a) to calculate the number of moles of DDT present in the canister. [A]

Given:

Required:

Analyse:

Substitute & Solve:

Paraphrase:

(c) Mayor Ford found a warning on the label saying: *"Poisonous. Do not ingest. Call poison control if more than 8.00 x10^24 molecules are ingested."* Use the magic triangle from Question 2(b) to convert the number of molecules into moles. If Mayor Ford accidently ingested the contents of the canister, should he call poison control? [A]

Given:

Required:

Analyse:

Substitute & Solve:

Paraphrase:

APPENDIX 2: Review of 1-step Mole Conversions
TEACHER'S COPY

Name: ________________

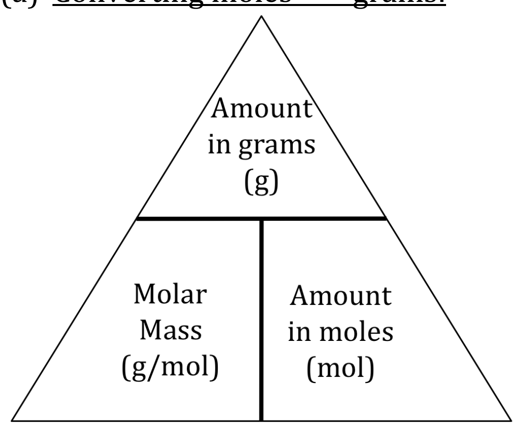
Date: ________________

1. Match the description on the left with a description on the right [K/U]

c_______	6.022×10^{23} entities	(a) 1000 g
e_______	12.01 g of carbon	(b) A chemist's dozen
f_______	molar mass	(c) Avogadro's constant, N_A
b_______	mole	(d) 0.1 g
d_______	100 mg	(e) exactly 1 mole
a_______	1kg	(f) Calculate using the periodic table
g_______	A handful of jelly beans	(g) A qualitative description

2. Last class we learned about **TWO CONVERSION FORMULAS** that can be used to describe the amount of a substance present. Fill in the missing labels (including units) on the following magic calculator triangles: [K/U]

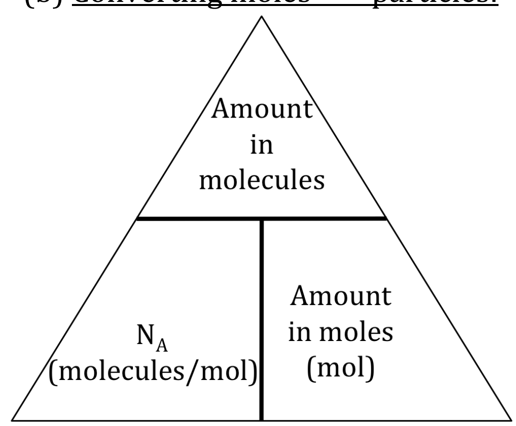
(a) Converting moles <-> grams:



FORMULA:

$$\text{Molar mass} = \frac{\text{Amount in grams (g)}}{\text{Amount in moles (mol)}}$$

(b) Converting moles <-> particles:

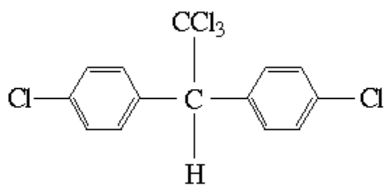


FORMULA:

$$N_A = \frac{\text{Amount in molecules}}{\text{Amount in moles (mol)}}$$

3. Last week, Mayor Rob Ford found a canister of pure DDT in his garage. The label indicates that the molecular formula of DDT is $C_{14}H_9Cl_5$. He observes that DDT is a white, crystalline powder with little odour, low solubility in water and relatively high solubility in fats.

(a) Calculate the molar mass of DDT. Remember to report your answer using appropriate units. [A]



$C_{14}H_9Cl_5$ = 14(12.01) + 9(1.01) + 5(35.45)
= 168.14 + 9.09 + 177.25
= 354.48 g/mol

(b) The label suggests the canister contains 0.100 kg of DDT. Use magic triangle from Question 2(a) to calculate the number of moles of DDT present in the canister. [A]

Given: Amount of DDT = 0.100kg = 100g
Molar mass (calculated in part a) = 354.48 g/mol

Required: Amount of DDT in moles

Analyse:

$$\text{Molar mass} = \frac{\text{Amount in grams (g)}}{\text{Amount in moles (mol)}}$$

Substitute & Solve:

$$354.48\ \text{g/mol} = \frac{100\ \text{g}}{\text{Amount in moles}}$$

Amount in moles = 0.282 mol

Paraphrase: Mayor Ford has 0.282 mol of DDT in the canister.

(c) Mayor Ford found a warning on the label saying: *"Poisonous. Do not ingest. Call poison control if more than 8.00 x10^{24} molecules are ingested."* Use the magic triangle from Question 2(b) to convert the number of molecules into moles. If Mayor Ford accidently ingested the contents of the canister, should he call poison control? [A]

Given: Amount in molecules = 8 x 10^{24} molecules
Avogadro's number = N_A = 6.022 x 10^{23} molecules/mol

Required: Amount of DDT in moles

Analyse:

$$N_A = \frac{\text{Amount in molecules (molecules)}}{\text{Amount in moles (mol)}}$$

Substitute & Solve:

$$6.022 \times 10^{23}\ \text{molecules/mol} = \frac{8.00 \times 10^{24}\ \text{molecules}}{\text{Amount in moles}}$$

Amount in moles = 13.3 mol

Paraphrase: Poison control should be called if 13.3 mol are consumed. As there is only 0.282 mol of DDT, Ford does not have to call poison control if contents were ingested

CHALKBOARD NOTE 2 – To be written after students complete *Review of 1-step Mole Conversions handout*

Teacher summarizes main review concepts for students:

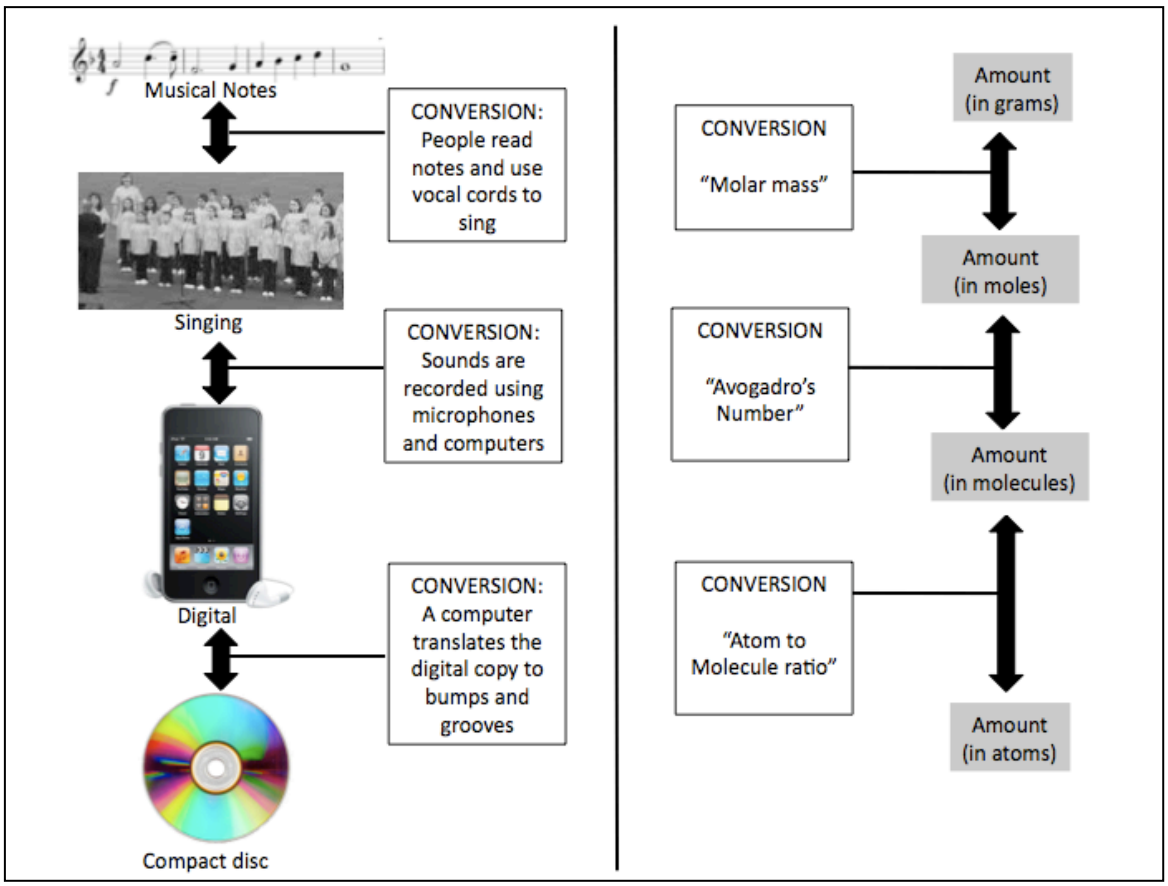
(a) The mole is used to describe quantities in chemistry
(b) Moles can be converted to grams or particles using the 2 magic triangles

APPENDIX 3: Creating Unique Mole Analogies

Name: ________________
Date: ________________

INFORMATION CAN TAKE MANY FORMS. HOW MANY DIFFERENT WAYS CAN YOU SAY THE SAME THING?

Take bars of music from the song, *O Canada*. If you have studied classical music you could read those bars to determine the melody of the song. What if you went to a Blue Jays game at the Roger's Centre and heard the anthem sang by a local choir. Would the melody have changed in any way? What if the choir was recorded live at the game, posted on iTunes, and a copy was downloaded to your iPod? What if you then burned a copy onto CD and listened to it on your CD player in the car? Have these conversions changed the melody in any way?



WANT TO KNOW A SECRET?

The trick to mole conversions is that you are not actually changing the quantity of the substance. You are changing the description of the quantity. Mole relationships are connected linearly and so you can interconvert the quantity of a substance using the conversion formulas. E.g. converting grams to atoms requires 3 conversions!

ACTIVITY 1

A. Create your own analogy for mole conversions

- In groups of 3 or 4, use your knowledge of molar mass, the mole and Avogadro's number to create your own unique analogy that describes the relationships between these measures of quantity.
    - Exemplar: 'O Canada' described on the previous page
    - Tip: Be as creative as possible.
    - Tip: Work together as a team. Make sure everyone has a chance to participate. Designate a person who will be in charge of writing down ideas, collecting materials, and making sure the task gets completed on time.
    - Consider: Will your analogy be linear? Will it be reversible?

Brainstorming and ideas to consider: Analogy: Justify your analogy. Give reasons why analogy is similar to the relationships between molar mass, moles and Avogadro's number: Reason1 Reason2

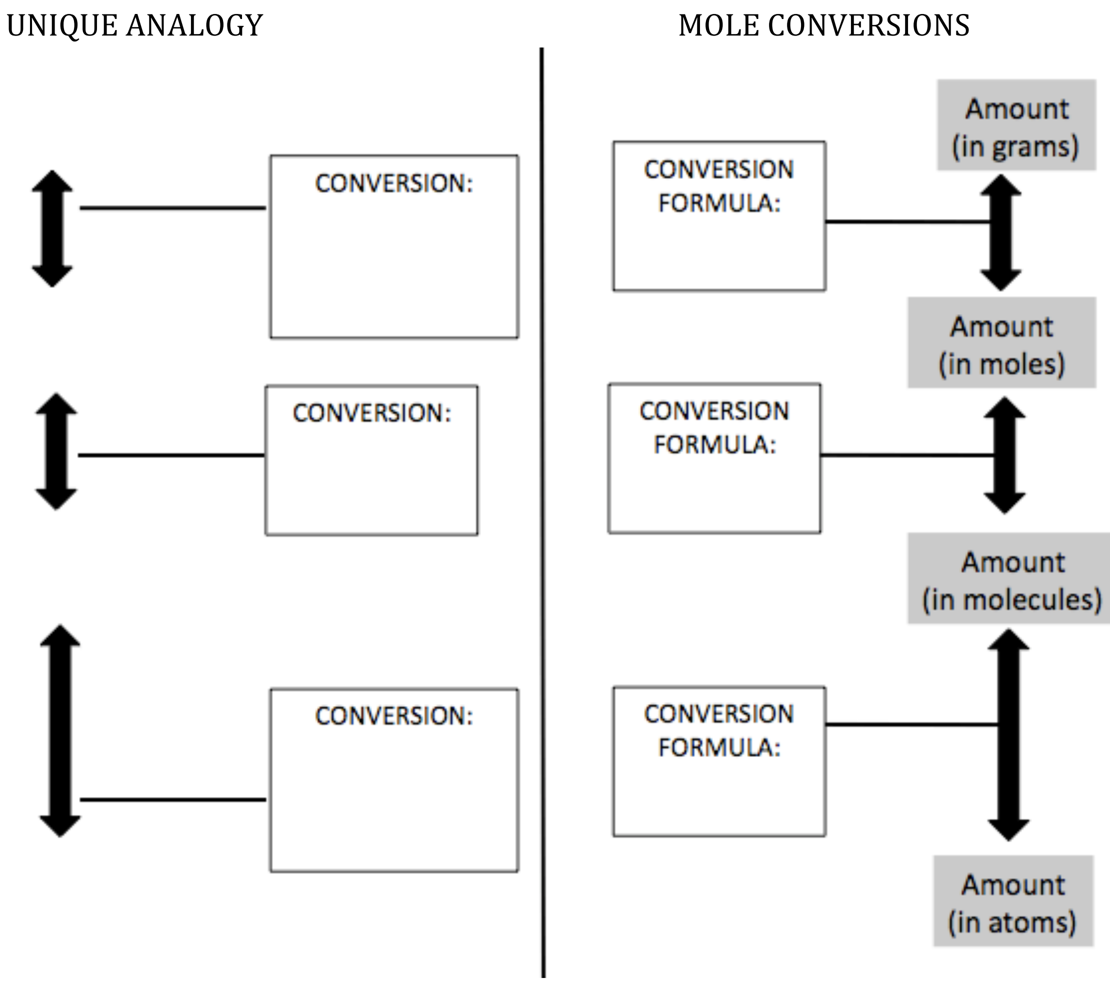
B. Present your analogy to the class

- As a group, present your analogy to the class in one of the following ways: [C]
    1. A visual illustration – Markers and chart paper available upon request
    2. A 30-60 second skit – E.g. A Rube Goldberg
    3. A graphic organizer – Templates available below in part C

- REMEMBER: All group members must be included in the presentation.

C. Graphic Organizer Template

- <u>Complete this section</u> only if you chose to create your analogy using a graphic organizer. If you chose to make a visual illustration or perform a 30-60 second skit, please IGNORE this section.



APPENDIX 3: Creating Unique Mole Analogies
TEACHER'S COPY

Name: ________________

Date: ________________

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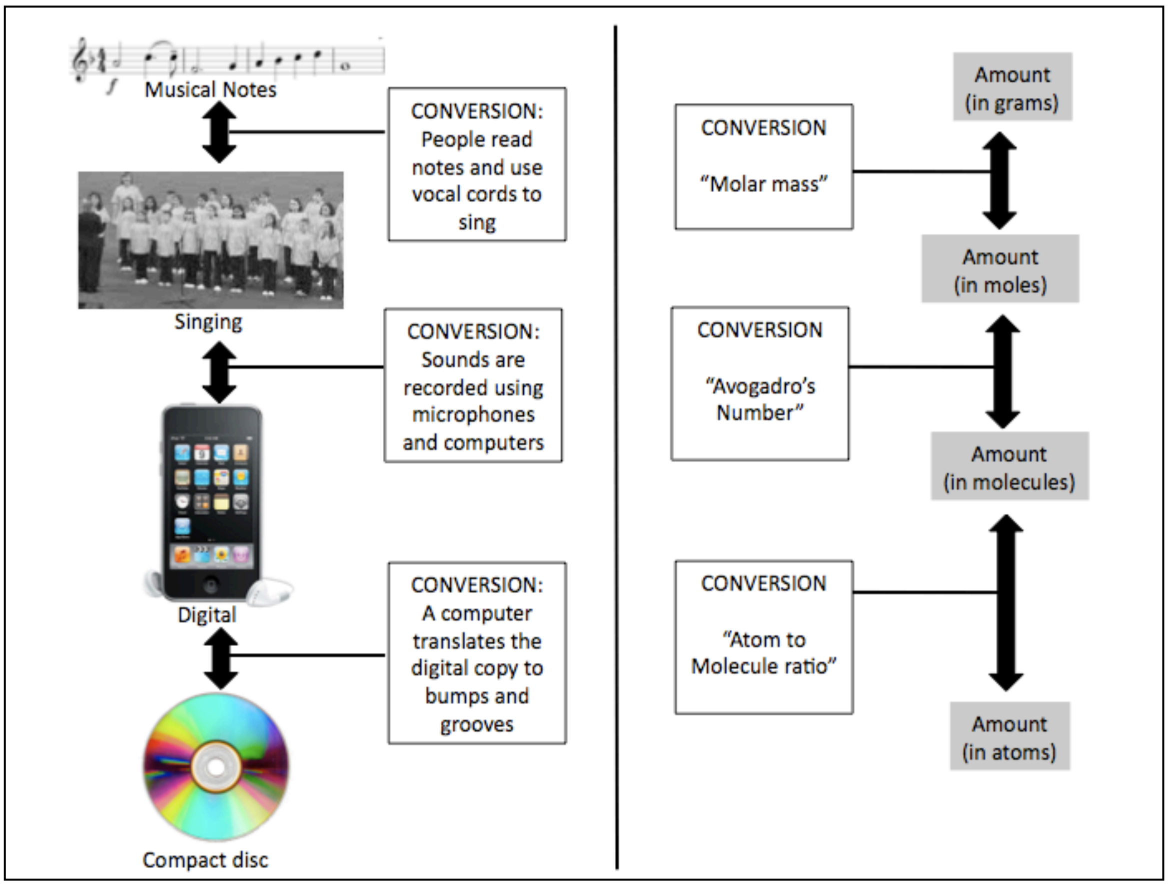

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    - Exemplar: 'O Canada' example described on the previous page
    - Tip: Be as creative as possible.
    - Tip: Work together as a team. Make sure everyone has a chance to participate. Designate a person who will be in charge of writing down ideas, collecting materials, and making sure the task gets completed on time.
    - Consider: Will your analogy be linear? Will it be reversible?

Brainstorming and ideas to consider: Translation of languages

Analogy: Mole conversions are similar to the translating of the word 'hello' in many languages. E.g. Writing a word down in Arabic, translating the word to English, saying the word aloud in English, saying the word in French.

Justify your analogy. Give reasons why analogy is similar to the relationships between molar mass, moles and Avogadro's number:

Reason1 The meaning of the word 'hello' does not change even if it is said in many languages. This is similar to the way that the quantity does not change despite converting the amount from grams to moles to particles.

Reason2 The analogy is reversible, just like mole conversions.

B. Present your analogy to the class

- As a group, present your analogy to the class in one of the following ways: [C]
    - IV. A visual illustration – Markers and chart paper available upon request
    - V. A 30-60 second skit – E.g. A Rube Goldberg
    - VI. A graphic organizer – Templates available below in part C

- REMEMBER: All group members must be included in the presentation.

C. Graphic Organizer Template

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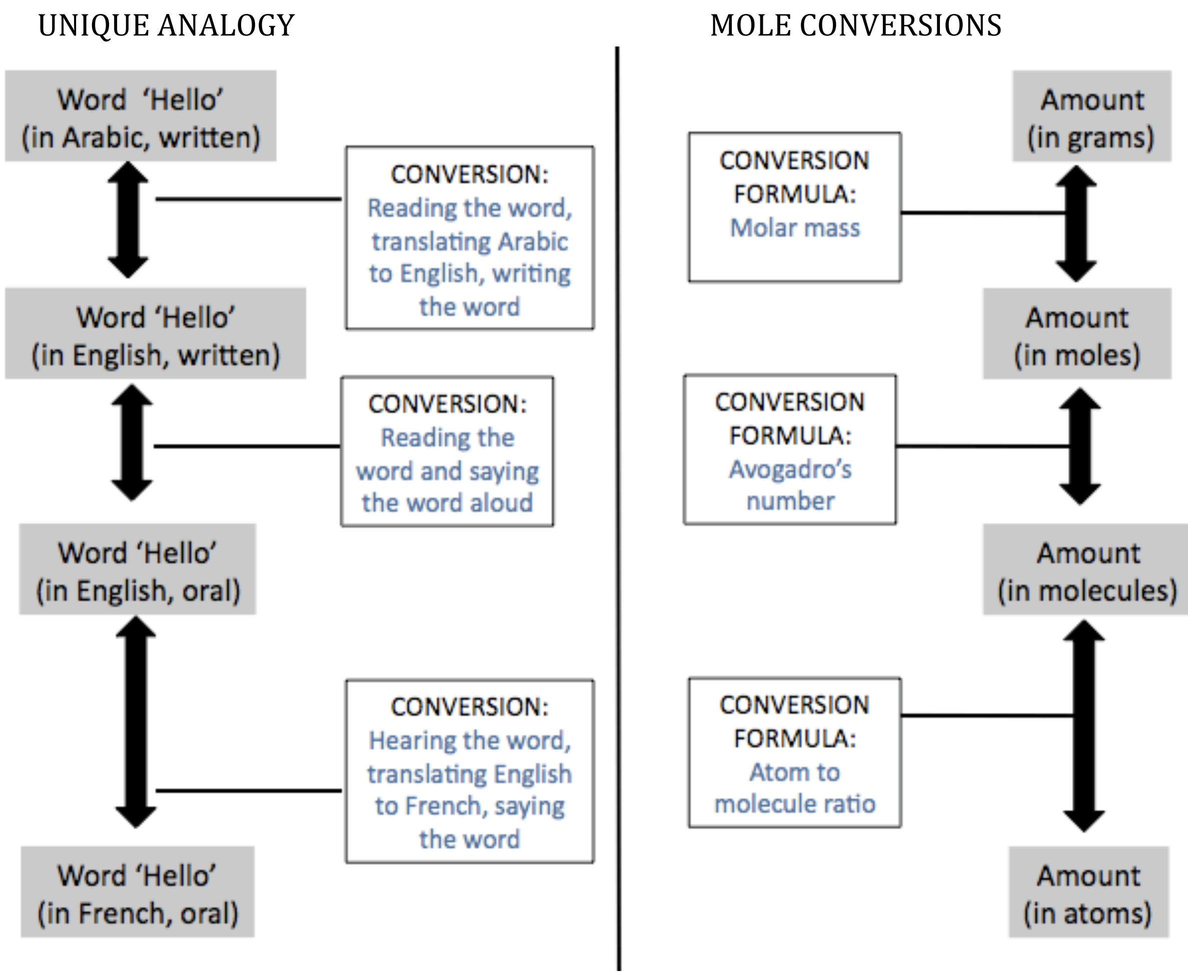

CHALKBOARD NOTE 3 – To be written <u>before</u> students complete Appendix 4-*Multi-Step Mole Conversions in Professional Settings* handout

<u>Conversion Class Sample Problem</u>

Imagine that you are working for Pzifer pharmaceuticals. You have been assigned the task of determining the mass that a single tablet of their new drug Phycasol (molar mass = 98.0 g/mol) should be. You know that you need 40.0 x 10^{24} molecules of this drug in one capsule for it to be effective. How many grams of Phycasol will you make each tablet?

$n = 40.0 \times 10^{22}$ molecules / 6.02×10^{23} molecules/mol
n = 0.6645 mols

n = m/MM
m = n x MM
m = 0.6645 mol x 98.0 g/mol
m = 65.1 g

<u>Refer back to original big idea:</u>

How are quantitative descriptions of Avogadro's number, the mole, and molar mass related and why are accurate calculations important to health care professionals, the environment and society?

APPENDIX 4: Multi-Step Mole Conversions in Professional Settings

Name: ___________________

Date: ___________________

PRACTICE PROBLEMS

1) You went outside one winter morning to find rust (Fe_2O_3) building up on your car! You scrape off the rust, measure it and discover that there is 30 000 mg of it. How many atoms of Fe are there in the rust that has built up on your car?

2) Plants rarely show symptoms of toxicity or adverse growth effects when copper (Cu) is found at 'normal' concentrations within the soil. Here is what happens when soil levels exceed 'normal' concentrations:

Amount of Cu (mg/kg of soil)	Effect on plants
150	Native and agricultural species begin to show chronic effects.
500-1000	Selective - only copper-tolerant species and strains can grow
2000	Most species cannot survive
3500	Areas are largely devoid of vegetation cover

What would happen to our crops if we constantly used a fertilizer that kept an average of 500.0×10^{23} atoms of copper/kg of soil in the ground at any given time? (Hint: use the atoms to find the mass of copper in a kg of soil then worry about the rest of the numbers above).

3) In an average bottle of water there is 0.500L (1 mL = 1 g) of water. Assuming the water is completely pure, how many atoms of hydrogen are there in the bottle?

APPENDIX 4: Multi-Step Mole Conversions in Professional Settings

TEACHER'S COPY

Name: ________________

Date: ________________

PRACTICE PROBLEMS

1) You went outside one winter morning to find rust (Fe_2O_3) building up on your car! You scrape off the rust, measure it and discover that there is 30 000 mg of it. How many atoms of Fe are there in the rust that has built up on your car?

m = 30,000mg = 30 g

MM = (56x2)+(16x3) = 160 g/mol

n=?

n = m/MM = 30/160 = 0.1875 mols

Molecules = 0.1875 x 6.022 x 10^{23} = 1.13 x 10^{23} molecules

Atoms = 1.13 x 10^{23} x 2 = 2.3 x 10^{23}

2) Plants rarely show symptoms of toxicity or adverse growth effects when copper (Cu) is found at 'normal' concentrations within the soil. Here is what happens when soil levels exceed 'normal' concentrations:

Amount of Cu (mg/kg of soil)	Effect on plants
150	Native and agricultural species begin to show chronic effects.
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3500	Areas are largely devoid of vegetation cover

What would happen to our crops if we constantly used a fertilizer that kept an average of 500.0 x 10^{23} atoms of copper/kg of soil in the ground at any given time? (Hint: use the atoms to find the mass of copper in a kg of soil then worry about the rest of the numbers above).

n = 7.0 x 1024 / (6.02 x 1023) = 11.6 mols

n = m/MM

11.6 = m/(63.5+16)

m = 920 g

therefore only Cu tolerant species will survive.

3) In an average bottle of water there is 0.500L (1 mL = 1 g) of water. Assuming the water is completely pure, how many atoms of hydrogen are there in the bottle?

0.5L = 500mL = 500g

n = m/MM
n = 500/(2 +16)
n = 27.78 mols

Molecules = 27.78 x 6.02 x 1023
= 1.672 x 1025

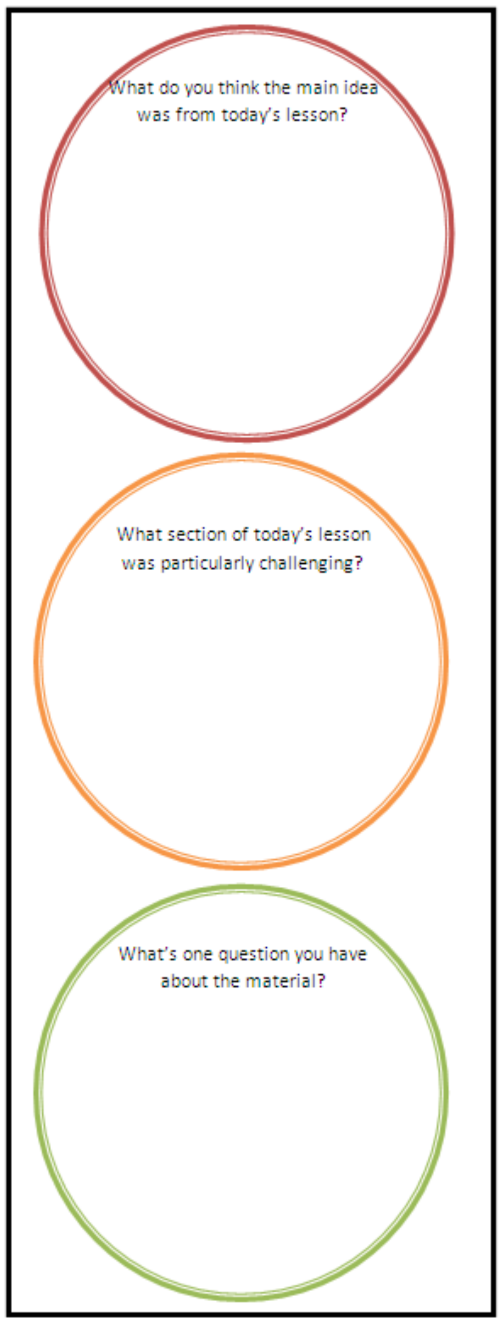
Atoms = 1.672 x 1025 x 2
= 3.34 x 1025

APPENDIX 5: Traffic Light Student Reflection

Name: ___________________
Date: ___________________

INSTRUCTIONS

Complete the following questions and hand in to your teacher before leaving class today.



CHALKBOARD NOTE 4 – To be written <u>before</u> students leave class

<u>Homework</u>

- Study for the quiz
  - What is a mol?
  - Solve 1-step mole conversions
  - Solve multi-step mole conversions

- Practice problems to help study for quiz
  - Chapter 6 Review, Questions: 22, 26-28, 30-36